CHOOSING A CAREER IN STEM

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Research conducted in many countries around the world has shown that there is a shortage of science, technology, engineering, and mathematics (STEM) university graduates leading to a shortage in appropriately qualified people in the STEM workforce. This makes the recruitment of talented young STEM graduates an ongoing challenge for STEM organisations.

As society is becoming more and more reliant on complex technologies, these declining enrolments in STEM disciplines and a lack of interest in STEM careers are cause for alarm. In addition to a decline in enrolment, there are high attrition rates in STEM courses, which play a major role in this current situation.

The shortage of qualified STEM people in the workforce, and the shortage of qualified science teachers, has led to a critical shortage of STEM professionals. This situation creates a need for greater understanding of how STEM career paths evolve and develop (Tytler 2007).

Choosing Science

Research on young people's career interests, interactions with science, and development of confidence in and identification with science indicates that many children, as young as six, associate mathematics and/or science as being "for boys", and that scientists are male.

Career aspirations are usually formulated during adolescence, and these aspirations lead to academic choices of STEM careers. It is unclear when these aspirations change, but research shows that five inter-related factors influence students' choices on whether or not to continue with science at school. These are: 1) students' engagement in previous school science, 2) their perceptions of the usefulness of science, 3) socio-economic factors, 4) gender preferences for some science subjects, and 5) the decreased relative popularity of science as a subject generally. Simply put, students are attracted to STEM courses mostly by personal interest, passion, enjoyment and practical application. Interestingly career prospects, salaries or the advice of others rated low when they were making their decision (Kennedy, Lyons & Quinn 2014; Lyons & Quinn 2010). However, even though there is an extensive body of research, we still have much to learn about why so many young people choose not to continue learning science or pursue careers involving science.

Positive school experiences such as good relationships with teachers or being shown how science is relevant in day to day life can also foster science aspirations. Similarly, there are close relationships between aspirations in science and family attitudes to science. Furthermore, in terms of influencers, teachers were rated as most important followed by parents and peers, whereas careers advisors were rated as the least important (Office of the Chief Scientist 2012, p. 53). Other factors contributing to observed differences and reinforcing STEM as a male activity include fewer opportunities and lack of support for women, science instruction and teaching methods that may favour males, environmental norms, and the lack of equality in employment terms.

In sum, these multiple strands of research show that students' interest in science and their experiences in school and within the family are inherently interconnected with structural factors such as gender, ethnicity and social class.

The situation for Chemistry

The decadal plan for Australian Chemistry (2016-2025), formulated in collaboration and consultation with chemistry's key stakeholders (Mulvaney 2016), noted that school education, at the primary, secondary and tertiary levels, was contributing barriers to the sustainability and growth in chemistry.

Most research is undertaken with students in secondary school, but research undertaken for the decadal plan for chemistry indicates that by the age of six, many Australian children already have a negative opinion of what the word "chemical" means with almost a third having a below-average knowledge of science subjects.

Furthermore, the literature indicates that factors that influence career choice in chemistry are thought to be similar to those related to choosing STEM careers, and (as discussed earlier) include social experiences, gender, ethnicity, social class, academic performance, and achievements.

For chemistry, particularly in the US, enrolment is low compared with other science or non-science fields. The reasons for this include the public image of chemistry, difficulties in learning chemistry at school, and negative perceptions of chemistry, such as "chemistry is dangerous". Chemistry students have also been shown to have inaccurate perceptions of chemistry in academia and industry. Furthermore, they are not familiar with potential career opportunities, and sometimes lack appropriate skills needed for a career as a professional chemist (Tucci, O'Connor & Bradley 2014).

In a recent study, Shwartz, Shav-Artza &Dori (2021) examined the personal, environmental, and behavioural factors that influenced the chemistry-related profession choice of 55 chemists, 18 chemical engineers, and 72 chemistry teachers. Using social cognitive theory (Bandura 1989) and social cognitive career theory (Lent, Brown & Hackett 2002) as a framework, the authors found that high school was a significant turning point of future career choices. Furthermore, self-efficacy in the task-oriented and chemistry learning aspects were the driving forces of choosing a chemistry career. Several factors were identified as influencing students' choice: 1) their interest in chemistry, 2) their achievements and

perceived capabilities – students who continue to study chemistry at university do so because they think they can be good scientists, and 3) their science teachers' encouragement.

On the other hand, there were several discouraging factors in students' choice in a chemistry career, including that science, and more specifically chemistry was seen as difficult compared to other subjects. The subject was seen to be intangible, hard to grasp, and requiring great investment, patience, and perseverance, and perceived as providing limited employment opportunities. These factors serve as barriers to students choosing a chemistry-related career.

In Summary:

Much of the literature is cohesive in terms of the key influences on students' choice of STEM subjects. These come down to personal interest, achievements and perceived capabilities, parents and teachers (or guidance counsellors) and the positive school experiences in science. These influences are mediated by inter-related structural factors such as gender, ethnicity and social class. On the other hand, several factors have been identified as contributing to observed differences, including fewer opportunities, inequalities in terms of employment and lack of support for women, teaching methods that may favour males and environmental norms.

Researchers agree that one of the best ways to increase STEM participation is to make the courses more relevant to daily life and to present the contents on a more personal level (Dawes, Long, Whiteford et al. 2015). In addition to relevance, science needs to be interesting and engaging. These findings align with research that found enjoyment, interest, success, value, and prior school experience are key factors in the choice of science at school.

A two-pronged approach to maximise interest and take-up of science is needed at specific year levels. Engagement strategies to create and keep the level of interest in STEM should occur in Years 7, 8, 9, but also importantly at a very young age, as research has indicated that perceptions are already in place as early as the age of six. Retention strategies aimed at keeping students interested in STEM should occur in Years 10, 11, 12 as this is the time students make their selections for university. Furthermore, to increase the pool of students, strategies targeting women and minority groups to improve their representation in STEM are necessary and include early interventions, getting rid of stereotypes, emphasizing the importance of effort over ability, connecting science with daily lives, role models, reducing academic barriers, and adjusting the work environment to family life.

Science is generally seen as difficult compared to other subjects and students who believe in their ability to obtain good marks, enjoyment and interest in a science subject are key factors in subject choice. Changes to curriculum, teaching, or programs to address students' attitudes toward science may take considerable time to translate into increased enrolments, but it is critical that schools begin implementing strategies that promote positive student perceptions of how interesting, enjoyable and useful science can be (Palmer, Burke & Aubusson 2017 pp. 658-659). These strategies need to be introduced at an early stage, as research indicates that the perception that science and/or mathematics is for "boys" is present among young primary school children. In addition, broadening students' views of the value of science, changing the

perception that science is difficult and giving students a clear path to future careers may go a long way in improving science subject choice among students.

Moving Forward: Creating a more inclusive STEM

Strategies aimed at increasing interest, relevance and building positive attitudes towards science need to be implemented at all levels of the Australian education system and need to be on-going. At a tertiary level, promoting STEM careers as being valuable and viable career path can be an effective strategy to 'unblock' the talent pipeline. One approach is internship programs which demonstrate chemistry career opportunities.

As an exemplar, the Master of Industrial Research program at the University of Melbourne and the University of New South Wales offers a cost-effective framework for chemistry businesses to host talented chemistry post-grads as interns for 12 to 18 months. This program, offered by the ARC Training Centre for the Chemical Industries (ATCI), helps our universities show our chemistry students that there is interesting and impactful work for them in industry.

Similar approaches such as the UnIChe (University-Industry Linkages in Chemistry) program have been successful as well. UnIChe was a collaboration between the University of Newcastle, the University of Melbourne and the Australian National University and Australia's largest chemical manufacturer, Orica Ltd and was funded by the Commonwealth Government for a three-year period (2003-2006). It is important that these types of programs are fostered and ongoing in order to provide a close connection between our secondary and tertiary education sectors and a rapidly changing industry.

Indeed, Australian science and innovation policy has seen numerous examples of schemes that have been successful, but these have generally been short-term programs, often grant driven rather than truly embedded in our policy systems. If the pipeline of good chemistry candidates is to flow, a long-term strategic commitment is needed. We have produced plans – we need all parties: government, academia and industry, to be dedicated to the success of these plans.

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